National Association of Forest Industries

Timber Manual
Datafile SS7

Architectural Timber Trusses

Revised Edition
2005

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Cover Photo: Large Oregon trusses form a spectacular roof structure of the foyer of a tourist resort complex. (Bolted trusses with concealed metal plates.)

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Introduction

The term Architectural Truss is used here to denote attractively detailed timber trusswork exposed to view. The frameworks may be light or heavy to suit the architectural theme. They could be left natural, oiled, stained or even highly decorated. Trusswork may be strictly triangulated or employ classic shapes that, while not being as efficient, echo the styles of past ages. Connections may be very much in evidence or concealed.

Architectural trusses are exposed frameworks intended to convey an impression of strength and tradition or, in contrast, a feeling of lightness. From a strictly economic point of view, slender trusses connected with toothed nailplates (refer Datafile P9 - *Manufactured Structural Timber Products*) placed close together (600-900mm centres) are more efficient in terms of timber utilisation than Architectural Trusses.

The normal nail plated truss is usually loaded (and restrained) on the bottom chord by the weight of the ceiling while Architectural Trusses usually carry the ceiling and roofing on the top chord. (Refer Figure 1)

Architectural Trusses are designed to create visual impact. For this reason they need to be spaced so that each truss is seen almost in isolation. Spacings of 3 m to 6 m are possible with conventional purlin systems while even wider spacings are more suited to glued laminated, trussed or ply-webbed purlin systems.

Services such as air-conditioning, ducting and lighting are usually exposed and need to be incorporated into the architectural expression.

Many of these trusses have demountable connections that facilitate transport either in a completely knocked down form or in more manageable sections that splice together quickly on site. For the same reason large nail plated trusses may require on-site bolted splices.

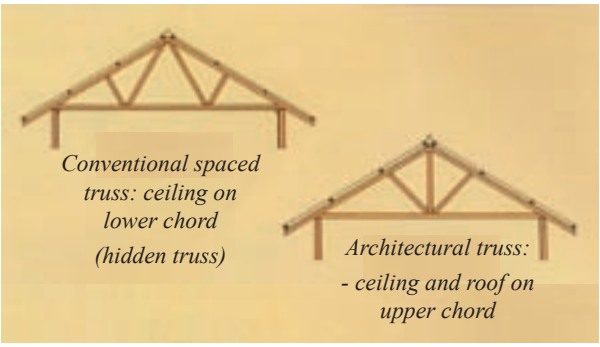
Shape Selection

Possible Configurations

The triangulated truss innovations of the 19th century were patented and many truss types still bear the name of their original designer, e.g. Pratt, Warren, Howe. The names used in this publication are consistent with European and North American texts.

Simple parrallel chord trusses provide lateral restraint to main trusses and support for extended timber ceiling. Trusses: Oregon Ceiling: Limed Tasmanian oak

Figure 1: Architectural truss compared with hidden truss



The design of the compression members often dictates the design:

- Can the member be kept stocky by choosing a truss style that has short compression members?
- Can it be designed as a spaced column to increase its resistance to buckling?
- Can it be fitted with some restraint to again prevent buckling?

Tension members require a few check points of their own:

- Can the connector end distance be achieved (especially with special connectors)?
- Should they be replaced by a steel cable or rod (to produce a more open structure)? Of course this may not be a possibility if some of the loading regimes produce compression as often occurs due to wind uplift.

Figures 2 - 8 provide some guidance as to the internal loadings. The members of the truss illustrations are colour coded to indicate the types of forces resulting in the members due to the weight of the roofing and ceiling.

- black indicates tension
- red indicates compression
- green indicates very little load in a web used for restraint of the lower chord.

It has been almost standard practice in contemporary timber construction not to carry the roof loading to the nodes but rather for the purlins and ceiling joists to load the top chord directly. As a result, the top chords carry a bending load as well as the axial load.

Figure 2 shows the possibilities for a pitched roof with a horizontal lower chord. All that varies is the number of webs and their orientation.

Figure 3 shows the development of a simple pitched roof. As webs are added the bending stress (and deflection) in the top chord is reduced. This results in several possibilities:

- a reduced size of top chord
- increased truss spacing (with the same chord size)
- increased spanning capability.

Traditional trussed roofs have steep pitches. This is due to design to shed snow and was influenced by the roofing materials of the time (e.g. shingles, slates and tiles). The loadings on the truss members and the connections are reduced when the depth of the truss is increased by steepening the roof pitch.

It may be that a heavy membered truss has a better appearance for a particular structure, while, for another, a fine framework may be more appropriate. The many variables already discussed make guide limits for maximum spans difficult but some guidance is contained in Datafile P9 - *Manufactured Structural Timber Products.*

The essential difference between Howe and Pratt trusses is that the Pratt is more efficient as it uses shorter compression webs. Both evolved for high bottom chord loading (which is not the case for most Architectural Trusses). Trusses with raised lower chords (refer Figure 4) heighten the space to give a feeling of spaciousness. A minor disadvantage is that they need stronger members and connections compared to those depicted in Figure 2.

The evolution of the Polonceau truss from the simple Collar Beam truss is illustrated in Figure 4. When these scissor type trusses are loaded, the support points tend to move apart horizontally and this needs to be considered in the design.

A pitched roof line can also be achieved using parallel sided trusses. Refer Figure 5. A field splice at the apex is often necessary for transportation.

Parallel chord trusses are appropriate for flat roof construction. Refer Figure 6. A slight pitch may be introduced on the top chord, or on both chords or graded purlins may be used to achieve fall to the roofing.

The versatility of parallel chord trusses can be used to advantage to support floors in mezzanine construction or as girder trusses carrying pitched trusses or rafters.

Lattice trusses create a fine screen that filters the light. The tension webs provide restraint to the compression webs they cross, making for a very lightweight solution. Figure 7 illustrates some alternative truss shapes.

All the truss shapes illustrated may be combined together, tilted or even inverted to produce an

Fine lines of light trusses allow maximum light through translucent roofing to outdoor dining area

Bolted parallel chord trusses create an interesting ceiling to banking premises. Note detailing of air condiitioning between truss webs

appropriate form. They may be fashioned into a space frame or arranged radially to form a variety of interesting patterns. Refer Figure 8.

When wind suction acts on a roof the lower chord of a supporting trusses changes from tension to compression and buckling then becomes a problem. Often bracing is necessary to stabilize this member but it often detracts from the chosen shape. Situations that tend to cause stress reversal in the lower chords of roof trusses include:

- lightweight roof-ceiling systems
- low pitched roofs
- high wind speeds

However, the designer has some control over the roof dead load and pitch and these may be manipulated to advantage in minimising net uplift in many situations.

A most attractive use of these trusses is when the roof volume is a source of natural light. These roof lights may take the form of:

- Conventional flat glass fixed in propriety glazing systems used vertically in traditional "North" sights or inset at the roof pitch.
- Conventional windows at clearstory or mezzanine level.
- Clear or opaque polycarbonate in moulded shapes or barrel vaults.
- Tensioned translucent membranes.

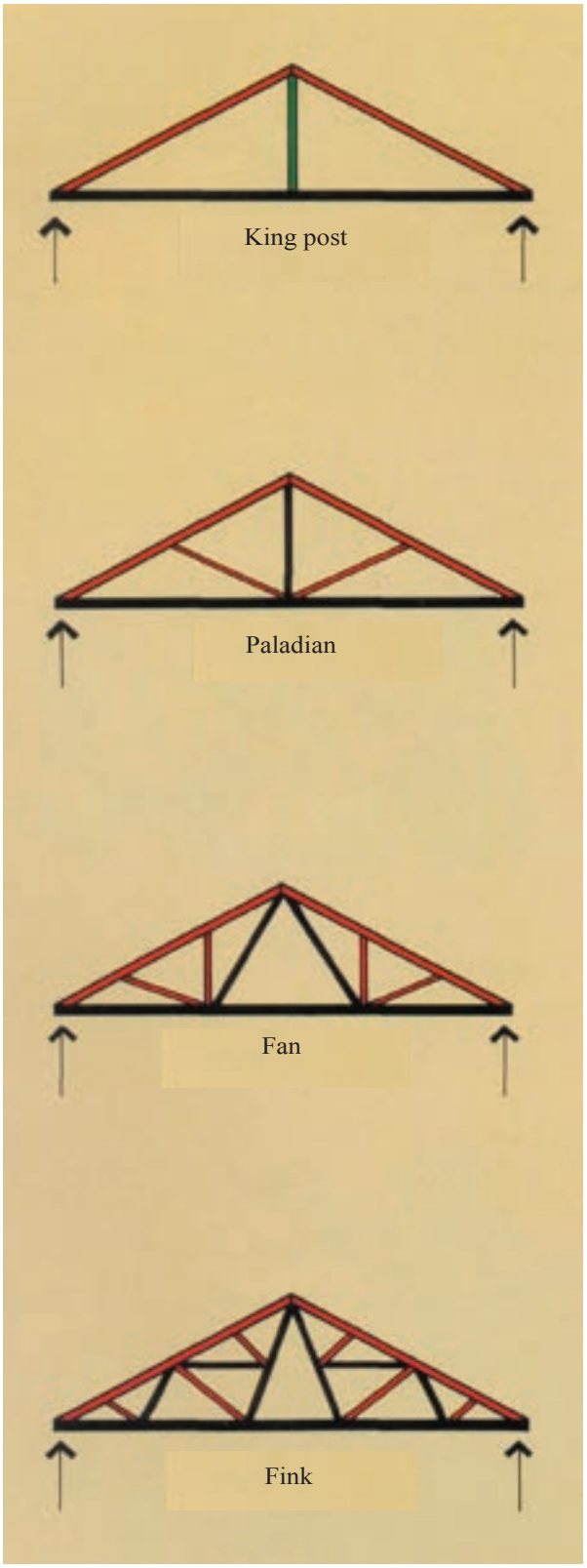
The supporting truss then needs to be sympathetic to these light wells by presenting an arrangement of webs consistent with this secondary structure.

Connection arrangements

In the detailing of the truss appearance, the following should be considered:

- the members, e.g. chucky timber or thin steel cable or rod (for tension members only),
- concealment or expression of hardware at the joints,
- multiple members,
- e.g. double chords with single webs single chords with double webs all single members,
- the number of members intersecting at a node (too many can be untidy),
- eave projections and the treatment of the upper chord at the heel joint, and
- the desirability of reducing eccentric connections. This is where the centrelines of members do not meet at a common point giving rise to extra loadings on members and connections. Refer to Datafile J1 - *Timber Joint Design*.

Figure 2: Pitched truss with horizontal bottom chords



Material Selection

The timber used for Architectural Trusses would normally be at least 150mm deep for chords and 100mm for webs and a minimum 75mm thick for single member trusses. Typical requirements include:

- large section sizes (200x100mm would not be uncommon)

Palladian trusses create light open roof space in modern church. Metal side plates are painted to blend with timber

Figure 3: Further develpment of truss shapes

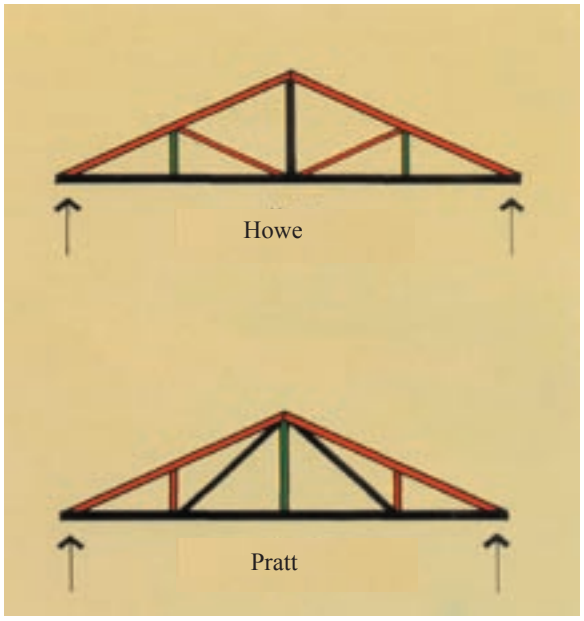


Figure 4: Pitched trusses with raised lower chords

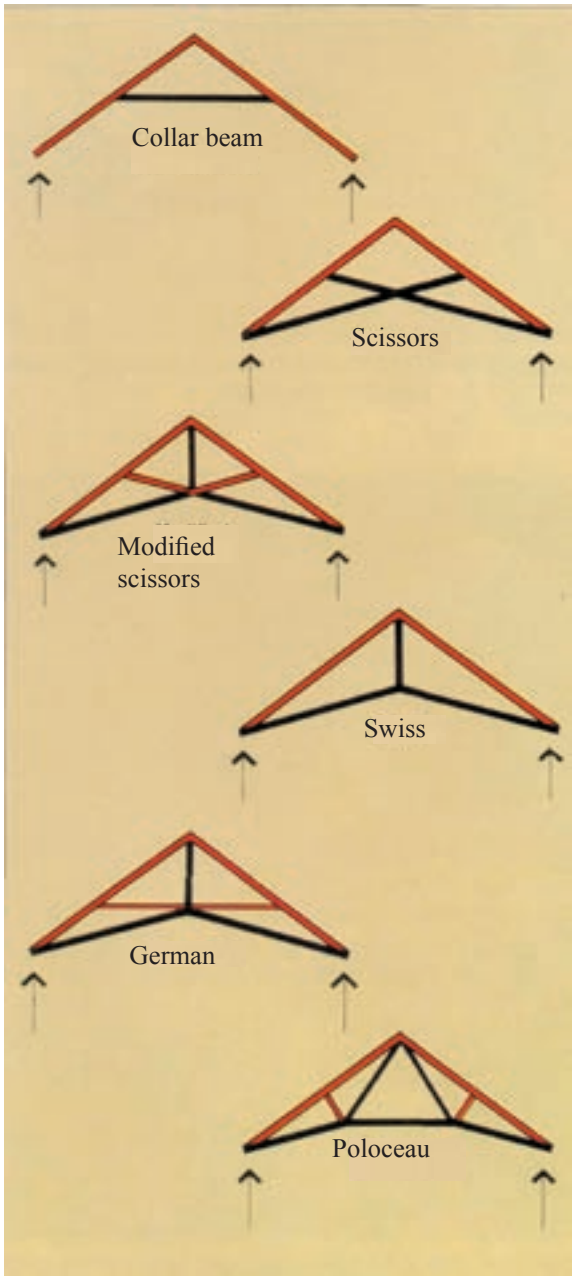
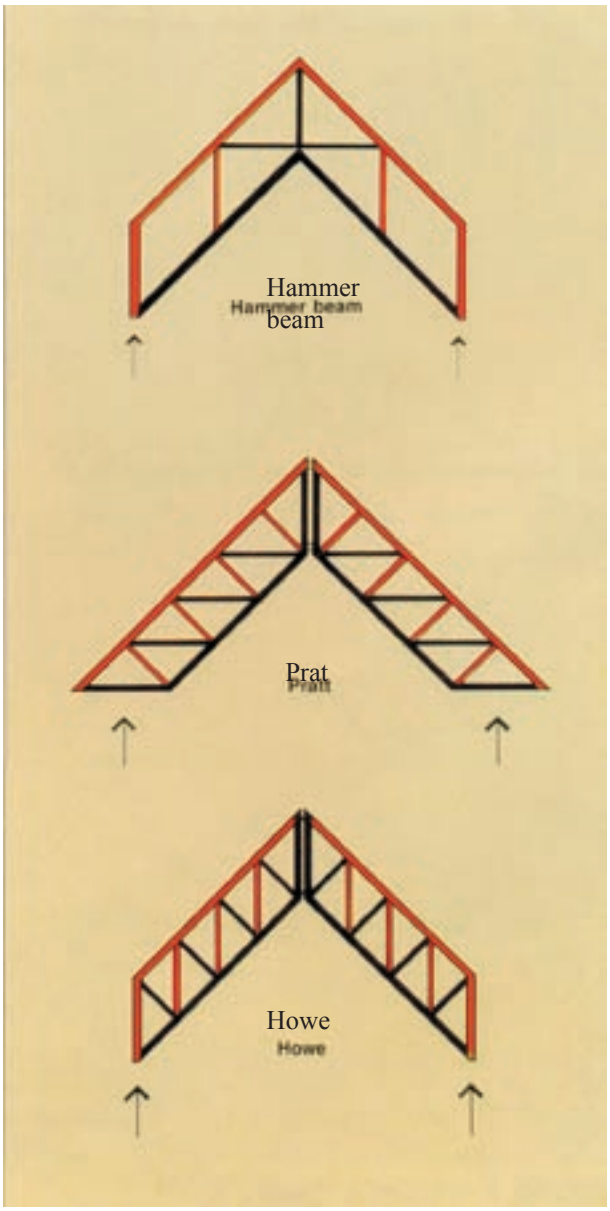


Figure 5: Parallel sided trusses



Nail-plated softwood trusses are a strong architectural feature in the Institute of Sports canoeing facility

Figure 6: Parallel sided trusses for flat roof construction

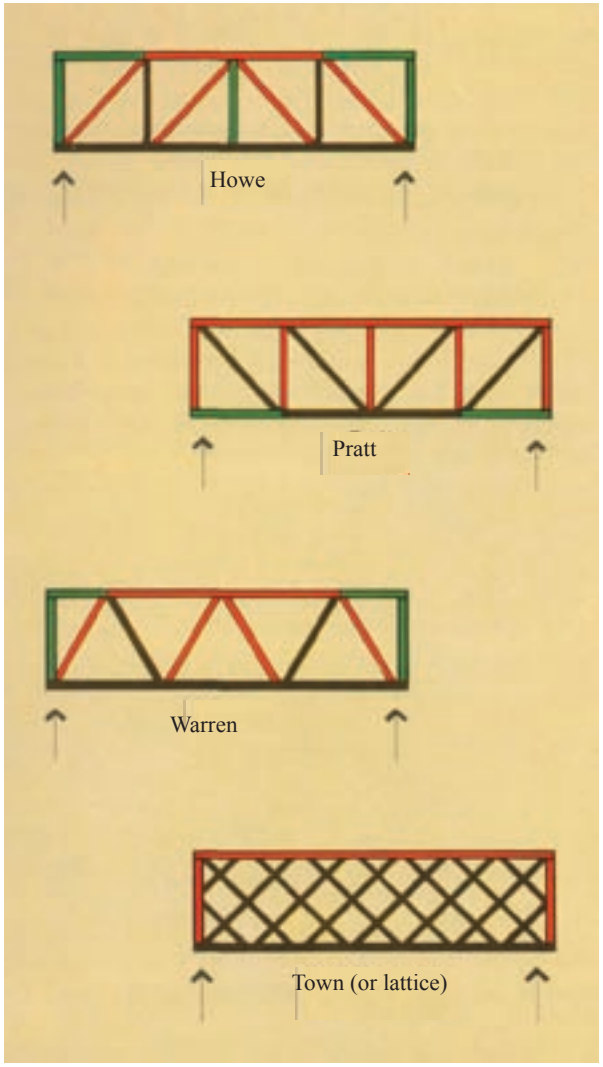


Figure 7: Other truss shapes

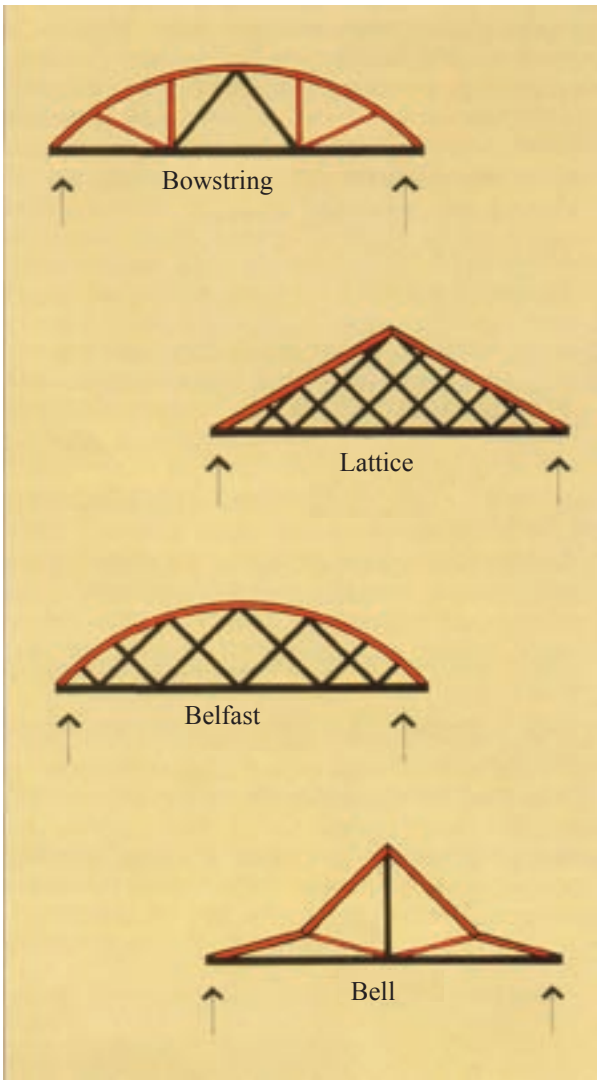
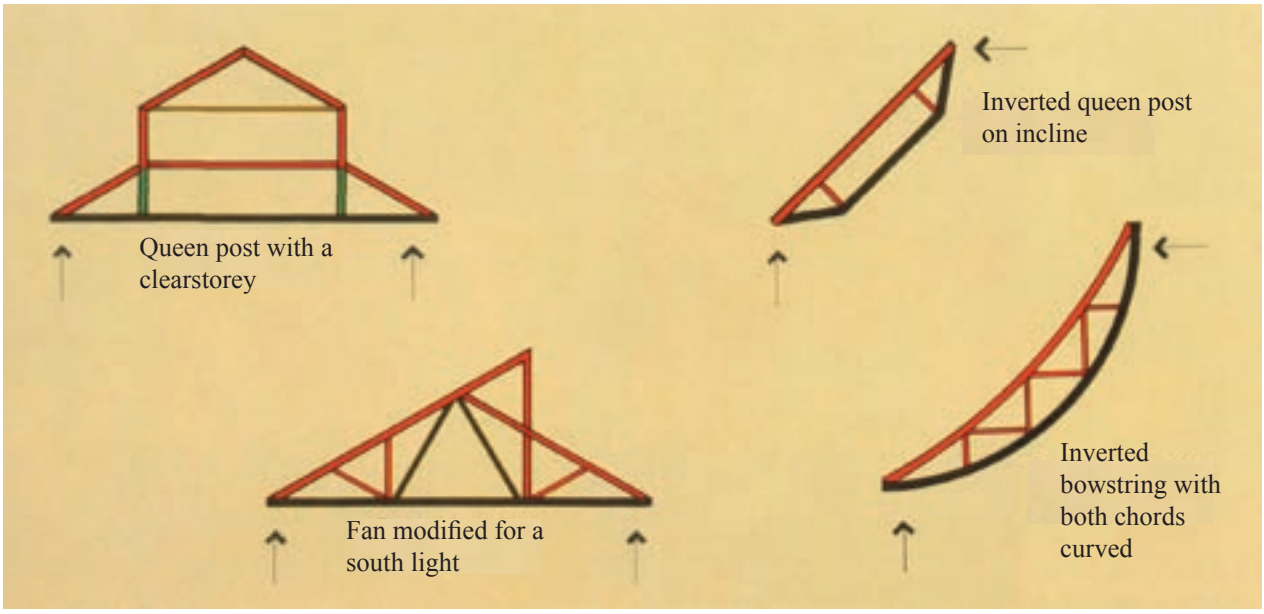


Figure 8: Combination of shapes


Queen post with a clearstorey
Fan modified for a south light
Inverted queen post on incline
Inverted bowstring with both chords curved

- long lengths to reduce unattractive splices (refer to Structural Design)
- clear timber in node locations

Unseasoned hardwoods are also suitable for these trusses. Care needs to be exercised in detailing to allow shrinkage movement to occur as members dry out. It is worthwhile not to commence fabrication until the moisture content has dropped below approximately 25%. The shrinkage of one member away from another at joints may also be aesthetically unacceptable. If this is a possibility, then either a different joint detail or seasoned hardwood in a multi-member system or glued laminated hardwood can be used.

There is obvious benefit in thicknessing sawn timber for truss members where connections are made using gussets and side plates. This results in a dressed exposed face. The combination of timber and steel materials can produce most aesthetic designs; timber for compression members and steel for tension members, can permit a variey of timber truss styles to be achieved.

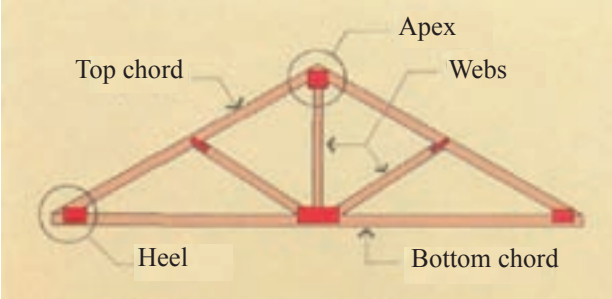
Where steel rods or cables can be incorporated in a truss design, they can contribute to simplicity in the joint design and give an openness in the appearance to the framework of trusses.

Timber trusses can have distinct advantages for use in buildings where the stored materials may give rise to environments that could be corrosive to steel. In such situation, the amount of steelwork can be kept to a minimum so that expensive anti-corrosion costs are minimised. (Refer figure 10). Glued laminated timber is an ideal material as sometimes the truss shape requires chord continuity at the nodes for stability and, accordingly, long length chords are required. Also since it is seasoned, and available in higher joint strengths, the connection detail at nodes can be more compact.

Laminated veneer lumber LVL is available in large depths but limited to 63mm in width. However, compression elements can be made up of multiple members if buckling presents a problem. Steel connection plates at nodes can be interleaved between the members for a very economic joint design. The appearance of irregular glued scarfed joints in LVL may restrict its use to painted trusses.

Softwood makes an ideal material since it is easily worked and its lightness enables the large sections to be manhandled. Low shrinkage is an advantage when fabricating from unseasoned stock. Seasoned softwood has the advantage of increased joint strength and enhanced stability but needs to be used in a multi-membered form as it is most commonly available in 45mm maximum thickness.

Figure 9: Truss nomenclature



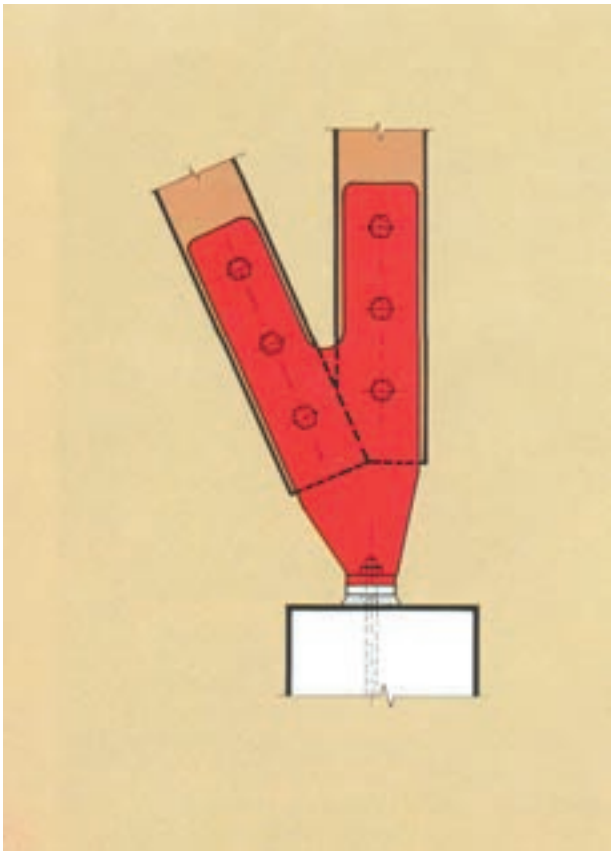
Connections

This section describes typical connections that can be used in timber trusses, for specific design information refer to Timber Datafiles *J1 Timber Joint Design -1 Design principles; J2 Timber Joint Design -2 Nials, Staples and Screws;* and *J3 Timber Joint Design -3 Bolts, Coach Screws and Timber connectors.*

Toothed Plates

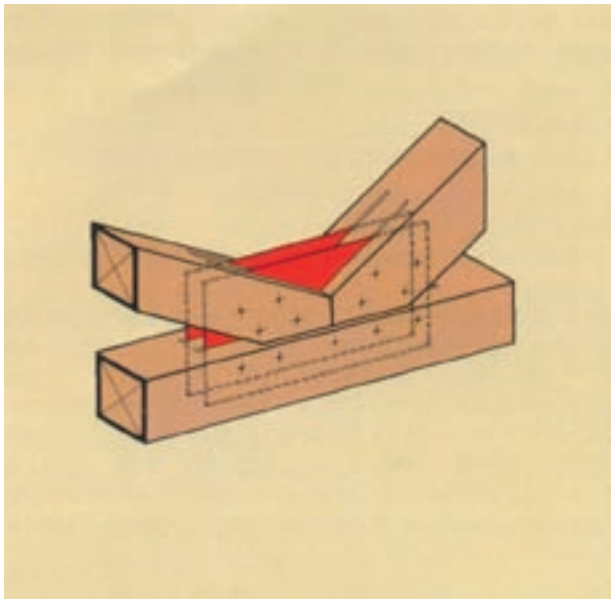
Toothed steel plates can be used for Architectural Trusses just the same as for the more closely spaced prefabricated trusses. As the truss spacing is increased or web numbers reduced, the joint loads increase.

Figure 10: Base fixing of trussed arch over swimming pool



Base detail of trusses over swimming pool. Metal fixing is kept clear of floor to prevent wetting

Figure 11: Typical interleaved plates



This means larger or more toothed plates are required. Usually a number (plies) of identical trusses are bolted together to achieve this. This assists in reducing the connector load and allows members to act collectively to reduce buckling.

Toothed plates are available in a variety of finishes to suit a range of corrosive environments. When timbers are clear finished or stained, the plates can provide a visual contrast especially when finished with a bright epoxy coating. When opaque paint systems are used, the plates blend with the truss members, and may be almost indiscernible.

Nails greater than 4mm diameter must be hand nailed (or rivet gun driven) while plates greater than 3mm thick must be pre-drilled or punched and are therefore not amenable to gun nailing.

Nails in Steel Plates

Nails make a most economic joint but the thickness of the architectural truss member makes it impractical to use a simple timber to timber lapped joint. Normal pneumatically fired gun nails can penetrate 2mm thick steel. While thin plates can be placed on the outside of members it is usually preferable to conceal them.

Creative use of heavy Oregon trusses in roof portecochere of major tourist project. (Ceiling limed in oak)

Refer Figure 11. It is possible to place plates either in saw kerfs cut into solid timber or between layers where multiple members are used. This mode of action can introduce double shear on the nailed joint, greatly increasing the joint's strength.

Dowels In Steel Plates

Recent European practice has been to use steel dowels 10mm to 16mm diameter, driven to a tight fit in steel plates in conjunction with seasoned timber. The resulting joint has increased stiffness but the joint is not demountable. It is worthwhile to include a few bolts to keep the assembly from spreading. This practice suits factory fabrication only.

Bolts

Architectural Trusses can be connected with bolts through overlapping timber members. While multi-layered trusses of this type can be quite efficient they may not be sufficiently attractive because of the spaces between the parallel members. Acceptable arrangements of Architectural Trusses of this type are limited to the following:

- single webs — double chords (this results in eccentric loading of the lower chord)
- double and single webs — single chords
- double and triple webs — double chords

A structural advantage of multiple members is that bolts are placed in compound bending effectively increasing the joint capacity. Compression members may need to be designed as spaced columns to further improve their efficiency.

On a practical note, double members (of lesser thickness) are more easily obtained from sawn timber than large single solid sections. The use of spaced members eliminates some of the need for lower chord binders and provide concealment for lighting and services such as wiring and fire protection. (Refer figure 12).

Since bolted joints have a marked decrease in capacity when the load is applied at 90° to the grain, the most structurally efficient arrangement of the members may not necessarily be the most appealing.

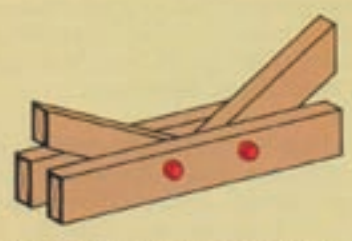
When a load is applied to a bolted timber joint the heavy steel washer provides a measure of restraint to both the head and nut. This increases both the stiffness and strength of the joint. The allowable loads for bolts that are tabulated in AS 1720 Timber Structures Code *Part 1: Design Methods* require the use of heavy washers. The washer reduces the bearing stress under the bolt head as the bolt cantilevers into the timber. Therefore, heavy washers should be provided whether the bolted connection is a simple timber to timber joint or split ring, or a timber to timber joint interleaved with a steel plate.

Standard square washers produce a traditional appearance but need to be neatly aligned while circular washers do not.

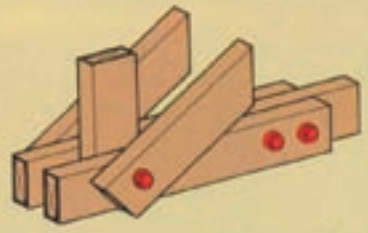
Bolts with Steel Side Plates

Thick steel side plates or gussets can be used for heavily loaded trusses. The load transfer is via the close fitting plates and this reduces the significance of loads

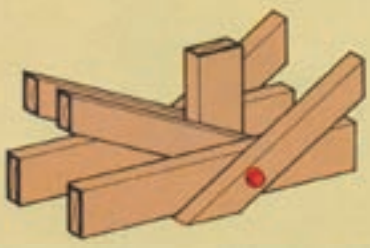
Figure 12: Multi member assemblies for bolted or split-ring or connected trusses



An eccentric joint where care needs to be exercised in the design
(refer Ozelton and Baird)



A five member joint where the central web load travels via the connector and the chord members to reach the outer (inclined) webs. This meanss that the load is applied close to 90 degrees to the grain



A seven member arrangement as could be employed in palladian or fan trusses

Bolted parallel chord trusses in shopping centre roof. Note the use of square washers

Bolted connection with recessed bolts painted black for emphasis

perpendicular to the grain.
Side plates may be fabricated by welding steel strip together or simply cut in one piece from steel plate. Bolt holes are usually drilled 1mm oversize. All metalwork needs to have a corrosion treatment appropriate to the hazard. This could include:

- no treatment if a rusty appearance is acceptable
- boiled in linseed oil
- paint system varying from simple primer only to zinc rich primer with vinyl top coats.
- hot dip galvanised
- galvanised together with a paint system
- stainless steel

When members meet at acute angles the minimum bolt spacings may require the gusset to become long and obtrusive. Also long gussets are of concern when secondary effects are considered since the rigid joint will not allow rotation. Then high loads perpendicular to the grain result. In such cases nodes could be articulated as in Figure 13.

In multi-member trusses the steel plate(s) can be hidden sandwiched between two or even three members. If the plates are painted in a neutral colour they become inconspicuous. In these cases the bolt heads bear directly against the timber and must have the heavy washers installed. The all bolted system requires long straps. Nailing the strap to the webs while retaining the bolted node is a popular European detail that makes the joint more compact because of the superior efficiency of nailed joints.

Special Connectors

The most common special connectors for use in trusses is the Split-Ring (refer to Datafile J3, *Timber Joint Design* — 3) and the Bulldog (or toothed ring). The latter has a restricted load capacity. As it needs to embed itself in soft timber it is only relevant to timbers in joint groups JD4/J4 and softer.

The Split-Ring operates as a large bolt while accommodating some shrinkage of the timber and is appropriate to both seasoned and unseasoned timber. In an economic comparison of fasteners toothed nail plates have the least installed cost ($/kN) while Split-Rings are one of the most expensive. Its major advantage is that a single row of Split-Rings allows rotation of a joint, unlike multiple connectors. As a result secondary stresses are minimised.

The usual arrangement in a three member joint is one bolt with a pair of Split-Rings; either 64mm or 102mm diameter. In splices, multiple connectors may be used with spacings as detailed in the Timber Structures Code.

A significant limitation to the use of Split-Rings is that of distance from the bolt to the end of a tension member, especially in unseasoned timber. The arrangement of the webs may have to be altered to reduce this effect.

Shear-Plates are used for the transfer of large forces to steel side plates (refer Datafile J3 - *Timber Joint Design* — 3). The Shear-Plate is embedded in a series of grooves specially cut into the timber only; the load being taken from the Shear-Plate into the bolt and thence into the side plate. The Shear-Plate is the most expensive of

all the special connectors.

Plywood Gussets

Structural plywood can be used in joining truss members. Either the gussete can be applied both sides of single timber members or can be used much like interleaved plates when multiple members are used. The aesthetics of the whole truss are influenced by the shape and finishing of the plywood gusset.

Tie Rods

Where a truss is not subjected to significant reversal of load, such as wind uplift, the tension members may be replaced with steel tie rods or cable. The short web members could be timber. If steel tube is used, often in the form of a telescopic post (for tensioning purposes), they are called a Polconeau truss (when pitched) or Barap truss (when applied to a straight beam). The lightness of the steelwork gives an open feel to this style of construction.

Traditional Carpentry Joints

Traditional connections involve sound carpentry skills. While the joint loadings are often accommodated without expressing the hardware, the use of steel straps can be both functional and decorative. Refer Figures 14 to 19.

In traditional construction the top chord did not extend beyond the support due to the complications of the highly stressed heel joint. If an eaves overhang was required then either, a member in line with the purlins was used or, when a secondary framing system was used, the rafters were placed on top of the top chord (as in Queen Post trusses), and simply cantilevered to form the overhang. Refer Figure 15.

Rod and Block arrangements are possible when the tension members of the truss are not subjected to bending loads or compression. Then rods are used for the tension members and sometimes as anti sag rods supporting the self weight of the lower chord. The lower chord itself may be a rod (or cable) in some configurations.

Structural Design

While it is usually structurally more efficient to subdivide chords equally, sometimes a more pleasing effect is achieved if all the webs are parallel. There can be some economy in the jig fabrication of identical connections to offset the cost of extra timber (if any). Also it should be borne in mind that often an inefficient truss shape may provide a better architectural solution.

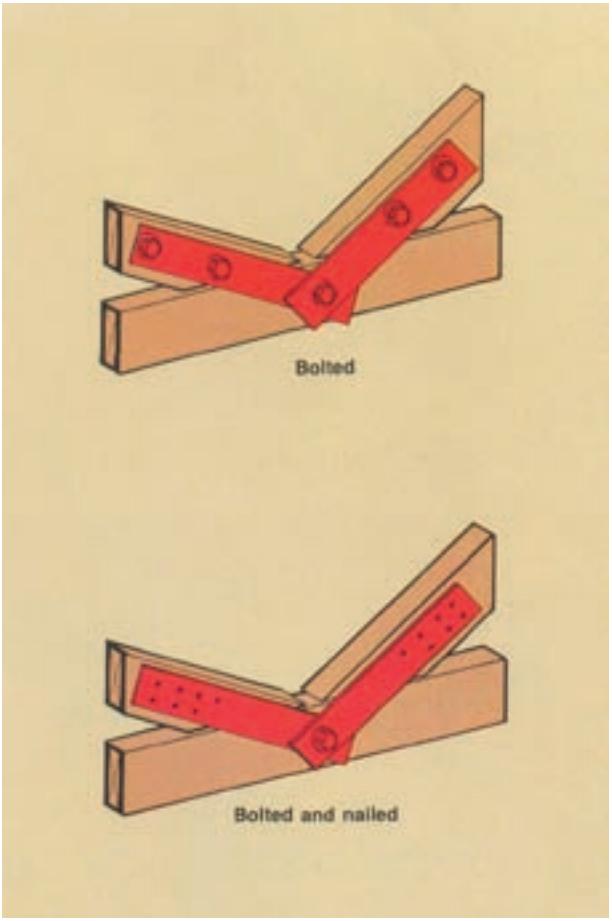
Most popular trusses are simply doing the work of a beam. With some inventiveness, triangulated frameworks may form a larger part of the structural building system such as arches or portals.

Refer figure 20 for details.

Truss Stability

A few traditional truss shapes are “unstable” if constructed with all the nodes pinned. That-is only moment splices are permitted in the chords as they are carrying significant bending moments.

Figure 13: Steel sided plates



Such trusses include:

- collar beam
- hammerbeam
- scissors
- queen post (to a lesser extent)

Analysis of these varieties may be done by more sophisticated methods such as Plane Frame with relaxation of moments at the (real) pinned nodes. Asymmetric loading may be the governing design criterion.

Analysis

While conventional truss analyses assume that all members are loaded at the nodes, it is a frequent occurrence in timber trusses that chord members are also subjected to a bending load caused by supporting

Complex radial truss system uses tension cables for lateral restraint and tie-down

roofing purlins. The framework may be analysed by conventional graphical analysis (Maxwell's Diagram) or Plane Truss programs with the effects of local member bending being superimposed. In some deflection sensitive configurations the effects of connection slip may need to be considered.

Pre-camber

Calculation of deflection is always warranted for Architectural Trusses. This becomes important visually for straight lower chords or where excessive movements may cause distress to other building elements or affect the building's serviceability. Calculations should consider creep deflection (load duration factors J_2 and J_3) as well as slip of the connections. These are most easily modelled with computer programs that incorporate the effects of fastener slip. Figure 21 shows an exaggerated distortion to illustrate the components of truss deflection.

Where dead load deflections are significant, the critical member can be pre-cambered. The lower chord (and

Figure 14: Traditional heel joints

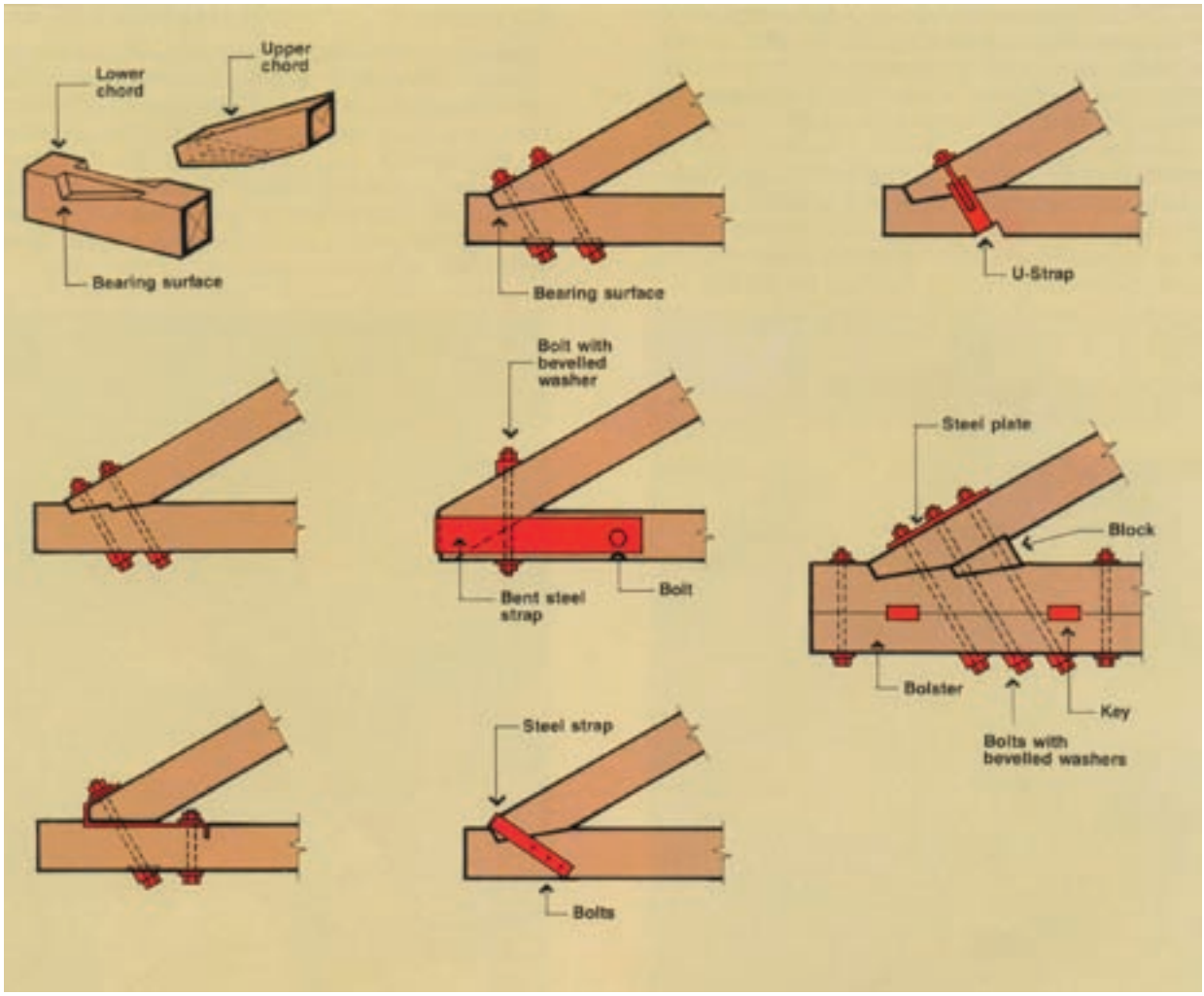
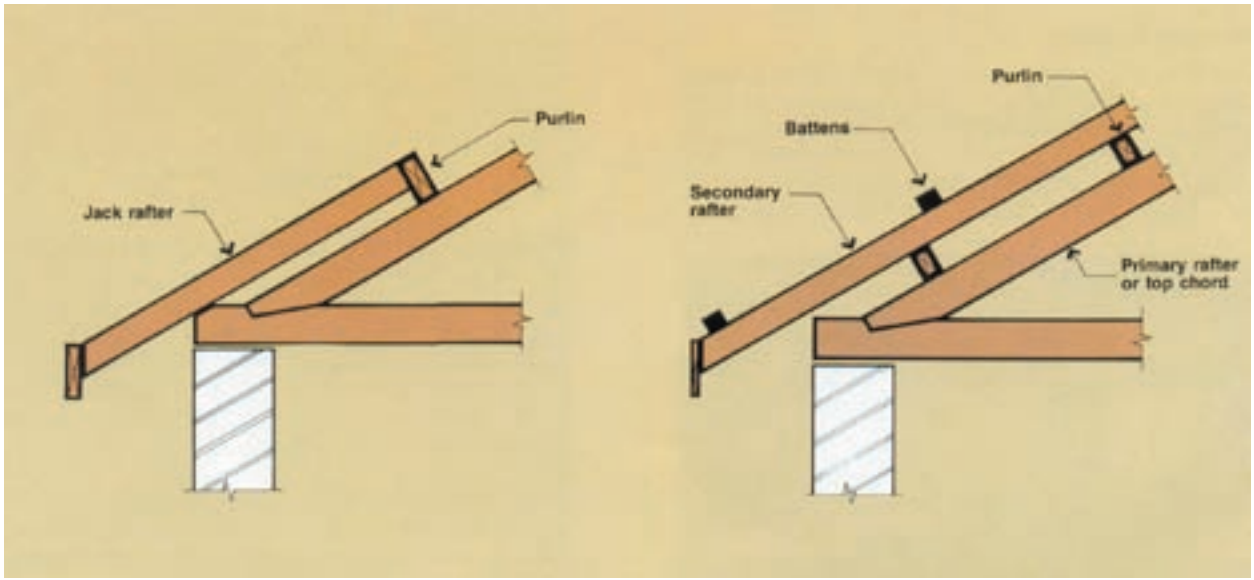


Figure 15 Eaves overhang treatment



sometimes the upper chord) can be bent upward at each internal node during fabrication so that, after the long-term application of load, the member will become straight.

Detailing

Often working drawings for architectural trusses need to show all the detail of workshop drawings. The member sizes and connector clearances and web inclinations all contribute to the uniqueness of each design. That is, a small change in web inclination may produce an unpleasant or unworkable node. For this reason typical nodes need to be drawn to scale to assess the practicality of each design especially with plated trusses. Simple alterations to member depths may have significant consequences at the nodes. Drafting techniques for structural timber detailing are shown in AS 1100 Part 501 *Structural Engineering Drawing*. Some of these

Figure 16: Traditional apex joints

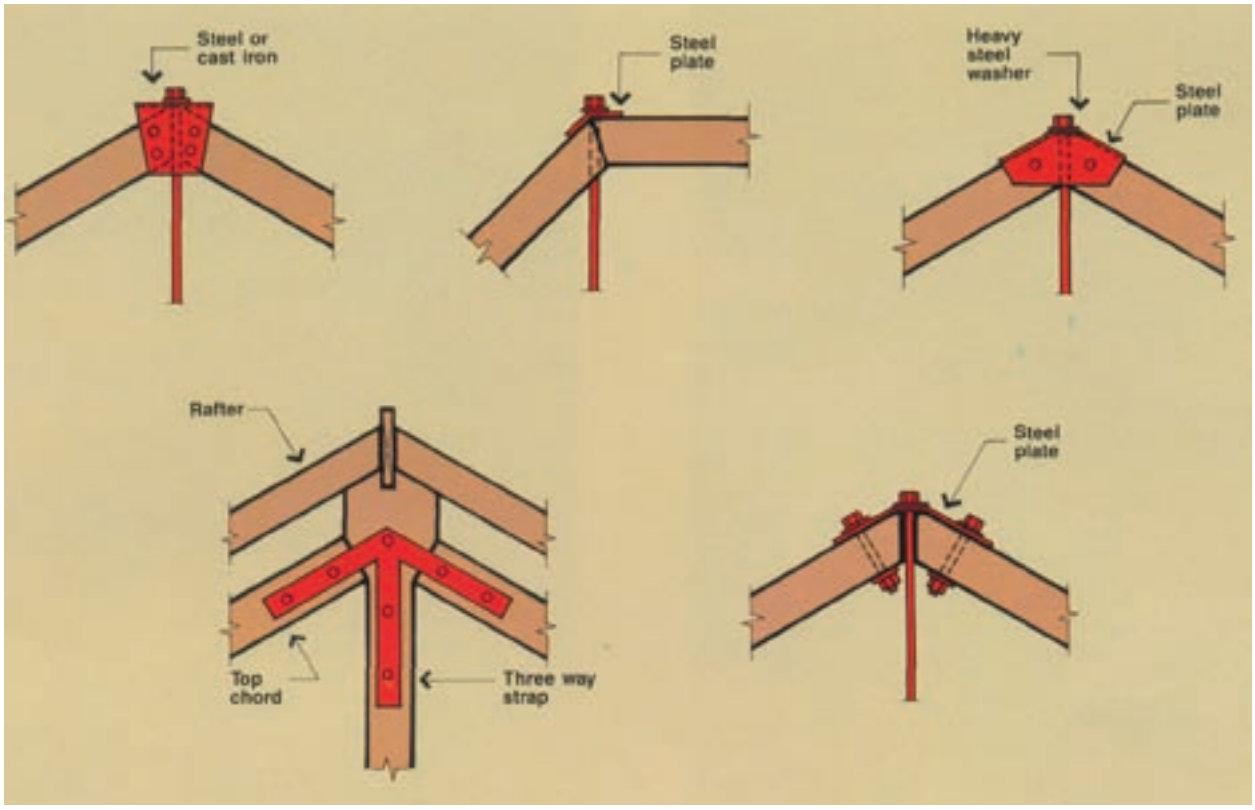


Figure 17: Traditional top chord - web joints

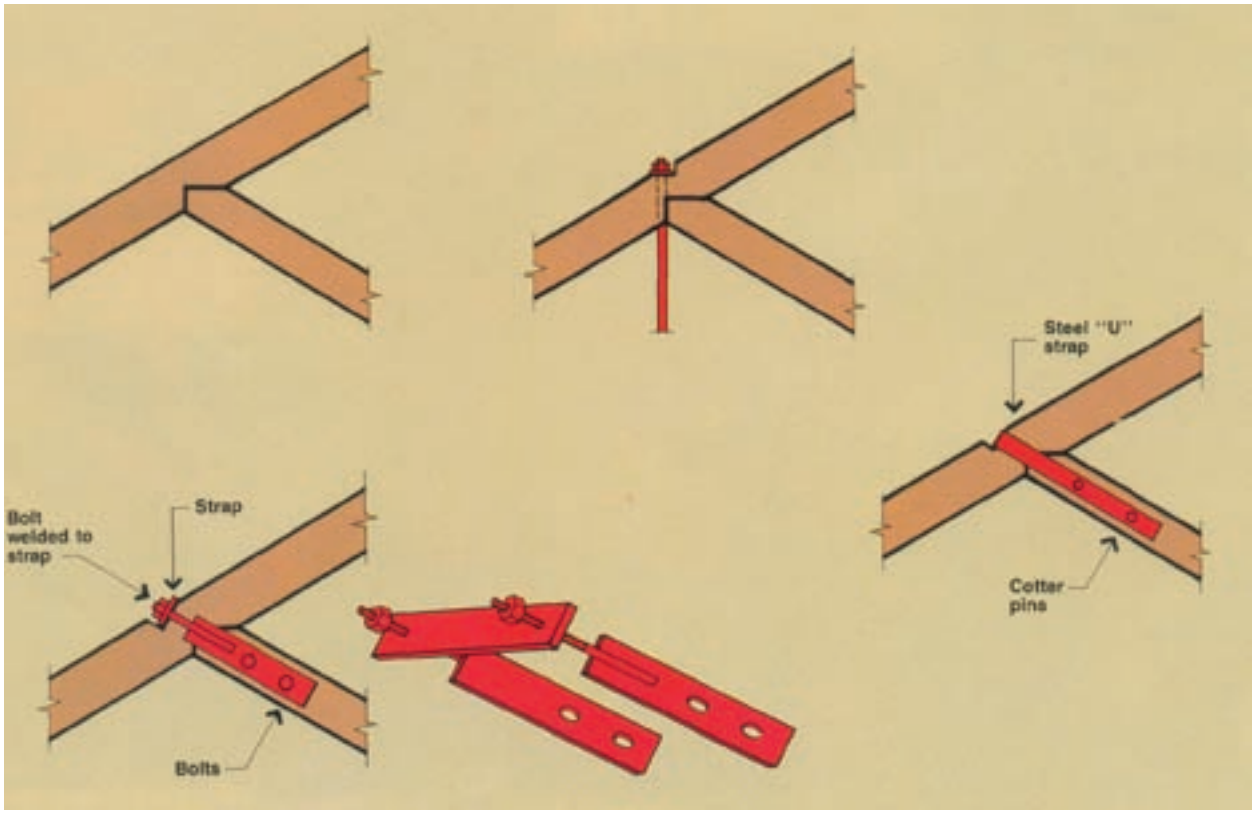
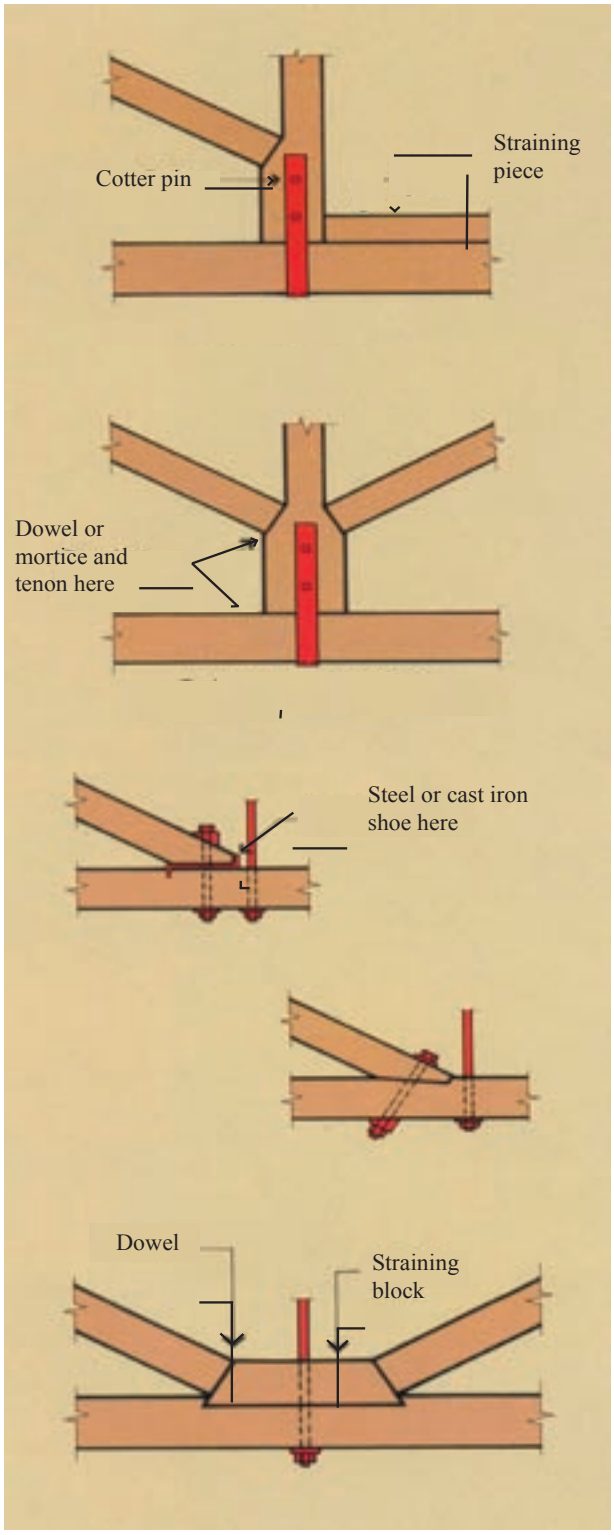


Figure 18: Traditional bottom chord - web joints



techniques are illustrated in Figure 22.

A technique to reduce timber splitting due to nail, dowel and bolt loads in line is to stagger them about their theoretical centrelines. This is illustrated in Figure 23.

Splices

Most sawn timbers are available up to 6 m long (and to 8 m with some difficulty and longer lead time). Handling considerations usually limit reconstituted timber such as glued laminated timber and LVL to 15 m, while sawn North American Douglas fir can sometimes be obtained up to 12 m long.

The truss span, chord arrangement and available timber lengths dictate the need to splice. This is more frequently required in the bottom chord since a pitched top chord is effectively spliced at the apex. Although the splice can be easily designed structurally, on occasions it can be visually irritating, especially if it is placed asymmetrically.

In these situations a glued laminated beam could be used; eliminating the need to splice. Alternatively another truss shape with a segmented bottom chord can be used, e.g. compound swiss truss. The effective splices then occur at the nodes making for a harmonious arrangement.

If a splice is necessary, the location should be chosen to minimise its structural significance. If the chord is in compression it should be spliced at the node where lateral restraint is provided.

If in tension, it is often located at about 20% of the inter nodal length to minimise deflection due to self weight. When significant bending loads are applied simultaneously then location becomes more restricted.

Bracing

In conventional roof construction, the ceiling (or ceiling battens or joists) provides a means of holding the lower truss chord in line especially when this member is compressed due to wind uplift. Architectural trusses possess an openness that by definition precludes the use of the usual timber binders or ceiling system to provide this restraint.

Lower chord restraint options include:

- Placing the lower chord on its flat
- Placing a beam on the flat forming a T-Beam with the bottom chord.
- Introducing a system of binders in sympathy with the services, e.g. ducting, sprinklers, lights, signs, etc. These may be timber or tubular.
- Using unobtrusive tie rods or cable to brace the nodes back to a stable element, e.g. end wall or wind truss or bracing wall.
- Designing the lower chord as a very wide spaced column that can carry the buckling load, over its full length.
- Altering the roof pitch or roof mass so that the uplift is minimised.
- Use bracing sets between adjacent trusses only
- Use fly bracing from ceiling line to lower chord.

Radial trusses meet at specially fabricated apex connector

Hold Down

It is normal for the support points to be exposed. Considering that they are spaced a significant distance apart, the forces to be transmitted can become substantial. For these reasons conventional tie-down using hoop iron or framing anchors are usually inadequate. Some typical hold down connections are illustrated in Figure 24.

Girder truss brackets produced for the toothed plated trusses may prove useful. Alternatively, specially fabricated steelwork is necessary to transmit uplift and lateral forces into the supports. Construction tolerances have to be accommodated and attachments using chemical anchors or even site welding may be appropriate.

Figure 19: Traditional tensio splices (in plan)

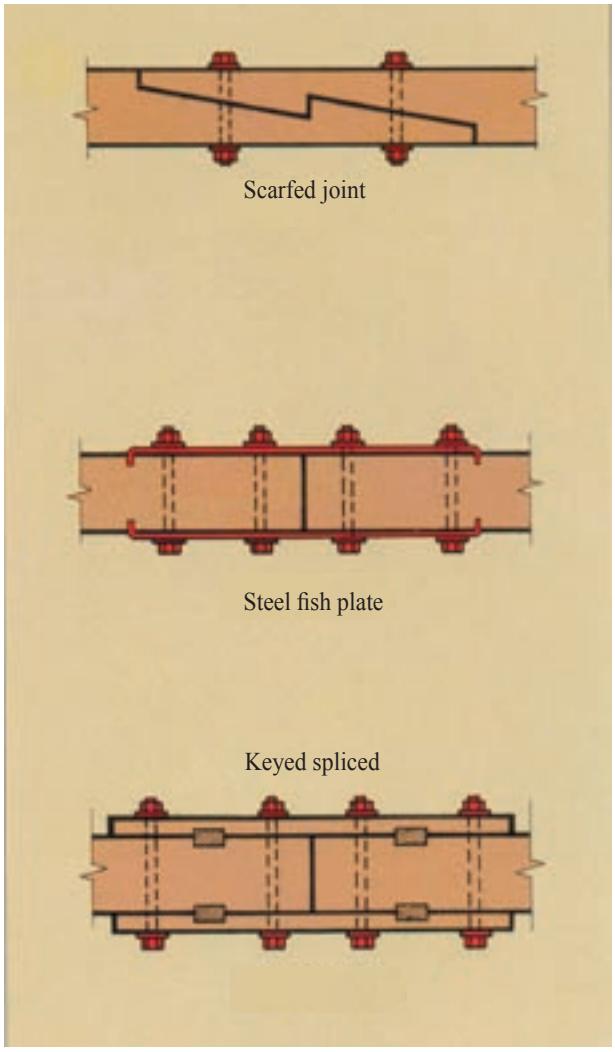
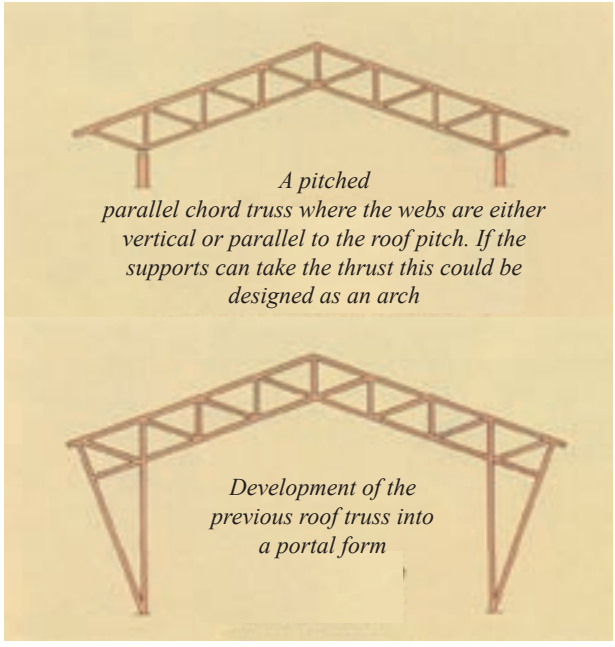


Figure 20: Arch portal trusses


A pitched parallel chord truss where the webs are either vertical or parallel to the roof pitch. If the supports can take the thrust this could be designed as an arch
Development of the previous roof truss into a portal form

Purlins

In general, purlins are more easily set above the top chord provided the truss has been designed for it. Refer Figure 25. Where the top chord is paired, the webs can penetrate the ceiling level to provide fixing to the purlins. For purlins not at nodes a simple block can project above the ceiling line while doubling as blocking for the spaced top chord.

Purlin hold downs have to be secretly fixed from above for this configuration. It could be a metal fastener with a screw fixing acting in withdrawal or simply a nailed block in low uplift applications.

Ceiling battens are necessary where the purlins are too far apart to provide adequate support to the lining. When purlins are above the upper chord, the battens are fixed under the purlins. This has an advantage in allowing concealed framing anchors to be used for purlin tie-down. When this is done the top chord is visually diminished by the batten and ceiling thickness and truss connections arranged on the chords centreline now appear asymmetric especially when the upper chord is relatively shallow. Top chord may be over-sized to compensate.

In some traditional applications a secondary rafter (taking all the bending) may be set above the top chord. The purlins may then be placed in line with the rafter.

The tops of the purlins can be set level with the upper chord allowing joins in ceiling material to be concealed. Refer Figure 25. The exposed purlins should then be stocky for the best appearance. Joist hangers or similar provide a suitable means of connection.

Exposed purlins can also support secondary rafters.

When the roof slope is greater than about 20° the component of the roofing and ceiling weight acting down the slope becomes significant. Then the purlins have to be designed for bi-axial bending or these forces resisted by bracing.

Heavy timber external truss with bolted metal plate connection. Note finishing colours to emphasise plates

Construction

Fabrication

Intricate detailing, hidden connectors and precise connector location all account for Architectural Trusses' aesthetics and structural performance. The high standard of workmanship required for these finely detailed frameworks makes the preparation of workshop drawings essential.

This high standard is normally attained only with factory fabrication. The use of jigs and templates is usually warranted to achieve the required precision so that the process of rematching components on site is eliminated. Additionally components should be marked or tagged for re-assembly.

For complex roof structures, trial assembly off-site may be beneficial to check the accuracy of fabrication.

Where unseasoned hardwoods are used some extra care needs to be exercised:

- moisture content should preferably be less than 25% at fabrication.
- wax emulsion sealers should be used on the cut timber ends so that rapid moisture loss is minimised, reducing the probability of end splitting provided that this does not present problems with finishing.
- bolt holes should be drilled 10% oversize and bolts, shear plates and split-rings should be well greased.

Particular care should be taken to preserve connector spacings, and end and edge distances as required by *AS 1720 Timber Structures Part 1: Design Methods*. Compliance with end distance requirements may mean that members beyond the soffit of chords.

Connection design strengths, computed in accordane with *AS 1720 Timber Structures Part 1: Design Methods* assumes that fasteners are not located in sections of timber containing visible strength reducing characteristic features (e.g knots and the like). This is easily achieved in reconstituted timber, but it is often a problem in knotty timbers and those with defects such as gum pockets and shakes. Therefore, the node positions where connections are to be in timber need to be carefully checked before timber is cut, so that the design assumptions can be checked for compliance and timber waste minimised.

In general, trusses should be assembled on the flat and some means provided to maintain the hog in the pre-cambered chords until all fasteners are installed. Once split-rings and shear-plates are installed they are difficult to detect and so a thorough inspection is necessary.

All exposed edges should be arrised to facilitate cleaning. Timber should receive the first finishing coat of any paint/stain before assembly. Final finishing may be done on site or in the factory depending on the handling procedures and the exposure on site.

It is feasible that the complete finishing of the timber can be carried out in the factory with only minor touch-ups on site. Once fixed on site access to all parts of the truss can become difficult.

Figure 21: Typical truss with exaggerated deflection

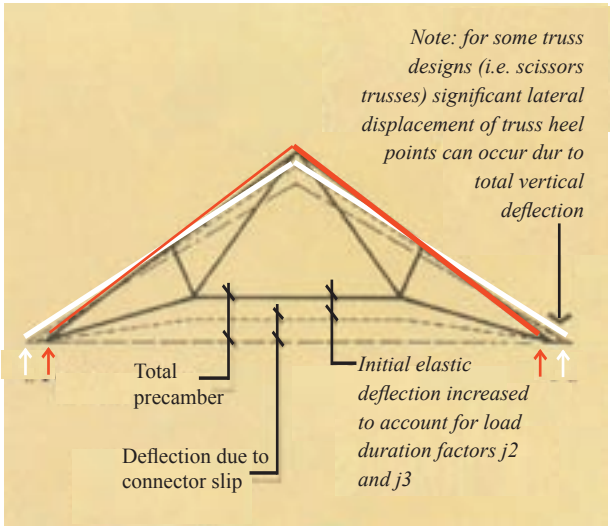

Note: for some truss designs (i.e. scissors trusses) significant lateral displacement of truss heel points can occur dur to total vertical deflection
Total precamber
Deflection due to connector slip
Initial elastic deflection increased to account for load duration factors j2 and j3

Figure 22: Representation of truss connections

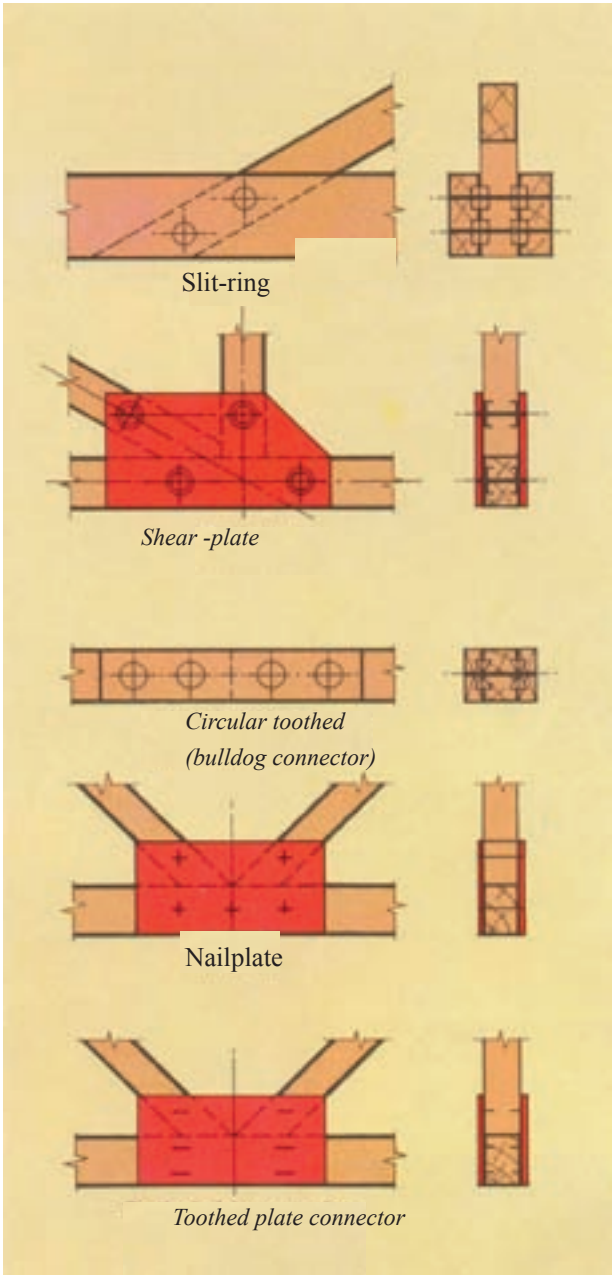


Figure 23: Technique to reduce splitting

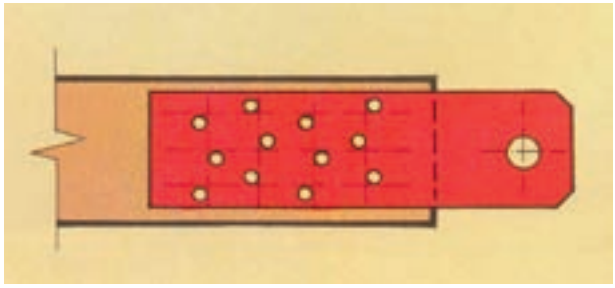
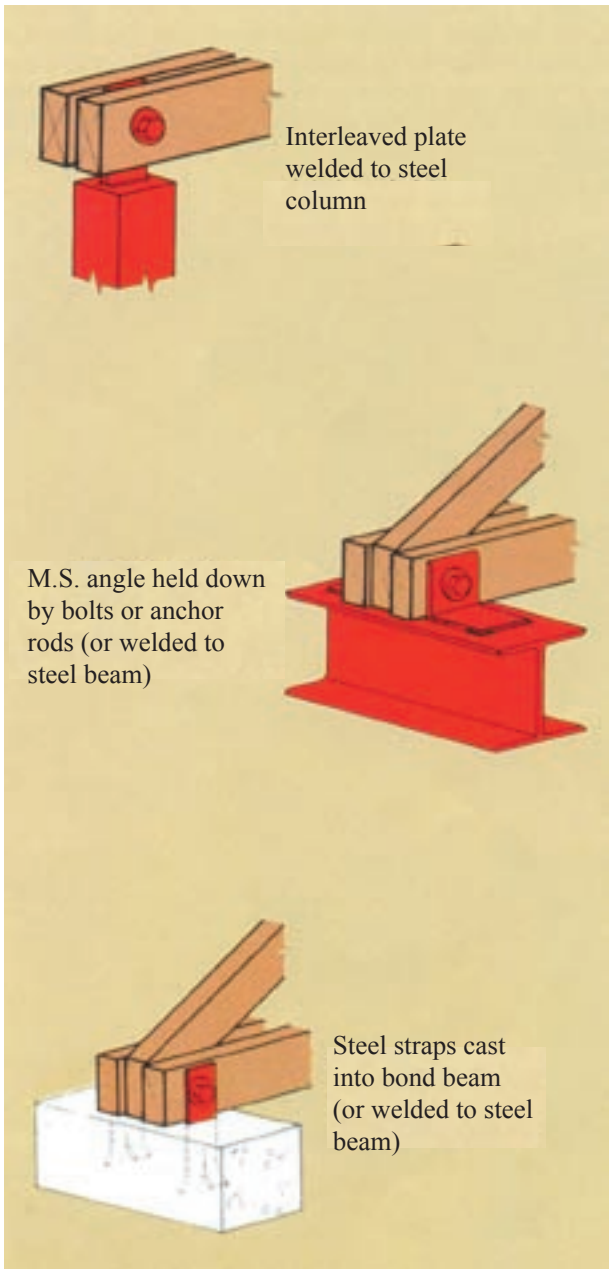


Figure 24: Hold down details


Interleaved plate welded to steel column
M.S. angle held down by bolts or anchor rods (or welded to steel beam)
Steel straps cast into bond beam (or welded to steel beam)

Nail-plated architectural trusses are painted to conceal plates and create light airy space

Transportation

Architectural Trusses are often shown to best effect in roofs pitched 30° or more and, given transportation height limits of about 4 m, this means a pitched truss of 12 m span or more has to be disassembled (in part or completely) for transport.

Trusses relying on factory nailed or dowelled connections are not suitable for disassembly unless they are used in combination with bolted nodes.

Complete disassembly can be an advantage in reducing transportation costs especially to remote locations such as tourist resorts.

When complete disassembly is necessary, the construction tolerances require that the members should be marked or tagged so that components from other adjacent trusses are not mixed during reassembly. Any marking should be compatible with the finishing details for the truss.

Traditional trusses have generous arrises on exposed edges and retaining this traditional feature also can reduce damage to the trusses during handling as well as making them easier to clean in service. Additionally, the finish to the truss should be protected during transportation and erection and may require water repellents, priming, or even protective wrapping.

Field Assembly

When the truss has to be assembled from its components in the field, a level working surface (usually the floor of the building) is required.

Supporting packing can be placed at least at each node and the components connected making sure that the pre-camber is achieved. Podgers (tapered shaft of a rigger's spanner) should be used to line up bolt holes rather than using the bolts themselves that may cause timber to catch on the threads and break out on the underside.

Care should be taken to ensure that all the special connectors and washers are installed before the truss is tightened. Bolts should be installed to simplify tightening of nuts, especially with unseasoned members.

Erection

Trusses should be handled using fabric or rope slings to minimise damage. Generally these trusses are sufficiently robust not to require lateral bracing during lifting but, once in position, some temporary braces should be installed to prevent overturning. It is possible to install purlins between pairs of trusses. They may be lifted together as more stable units but this depends on the design, site access and crane availability.

Finishes

Possible finishes to the timber include:

- none — natural sawn or dressed
- clear water repellent to reduce staining during exposure before the roof is complete
- waxes, clear polyurethanes (matt, satin and gloss)
- liming
- stains
- opaque paints

Steel plate finishes include:

- natural
- japanned
- boiled in linseed oil
- primed only (red iron oxide or zinc rich industrial paints)
- opaque paints subdued or vibrant
- epoxy paints (available in limited colours)
- hot dip galvanised (can be used with a paint system)
- stainless steel (dull or polished)
- powder coatings in various colours
- zincalume, colourbond and marviplate for thin sheet steel

Bolt finishes include:

- natural
- boiled in linseed oil
- zinc plated
- hot dip galvanised
- stainless steel

Specifications

Detailed specification clauses are contained in Datafile SP1 - *Timber Specifications*.

The following is a check list of data to include on the plans, workshop drawings or in the specification.

- *Strength Group, Stress Grade and Joint Grade of timber Nominated species/chemical treatment*
- *Appearance grade and surface finish of timber (especially for clear finishing)*
- *Tolerances and workmanship Fastener type, size, length, allowance for shrinkage (if any)*
- *Washer type/size Corrosion protection for metalwork and fasteners*
- *Edge and end distances and spacings*
- *Hole sizes Moisture content at fabrication*
- *End-grain protection*
- *Pre-camber*
- *Hold down detail*
- *Purlin sizes and attachment details*
- *Timber finishing, e.g. staining, painting*
- *Bracing*
- *Erection procedures*

Figure 25 Purlin above chord

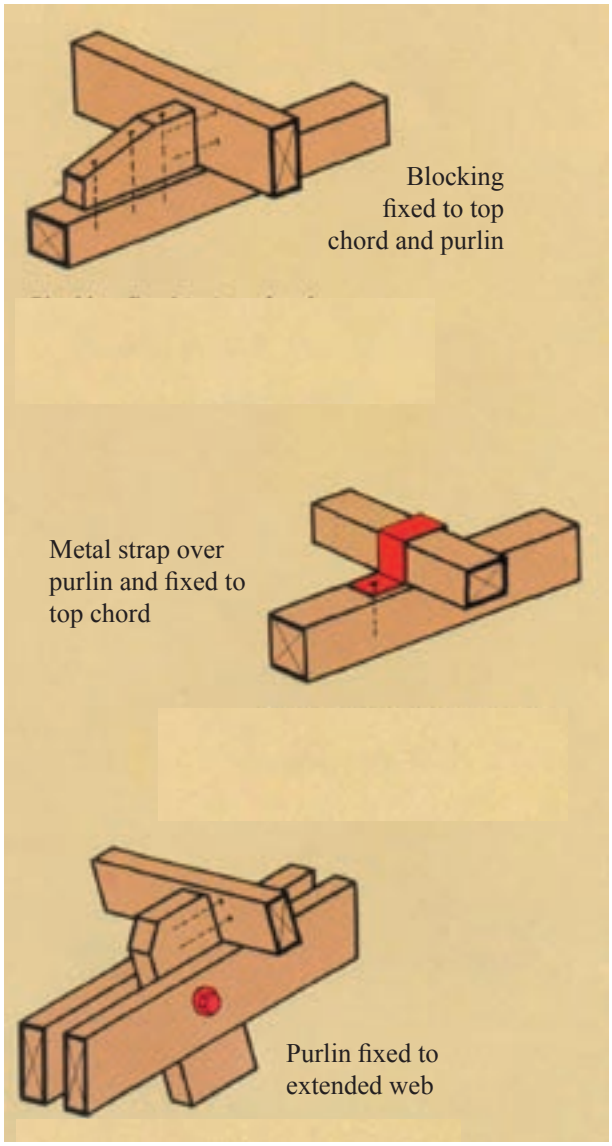
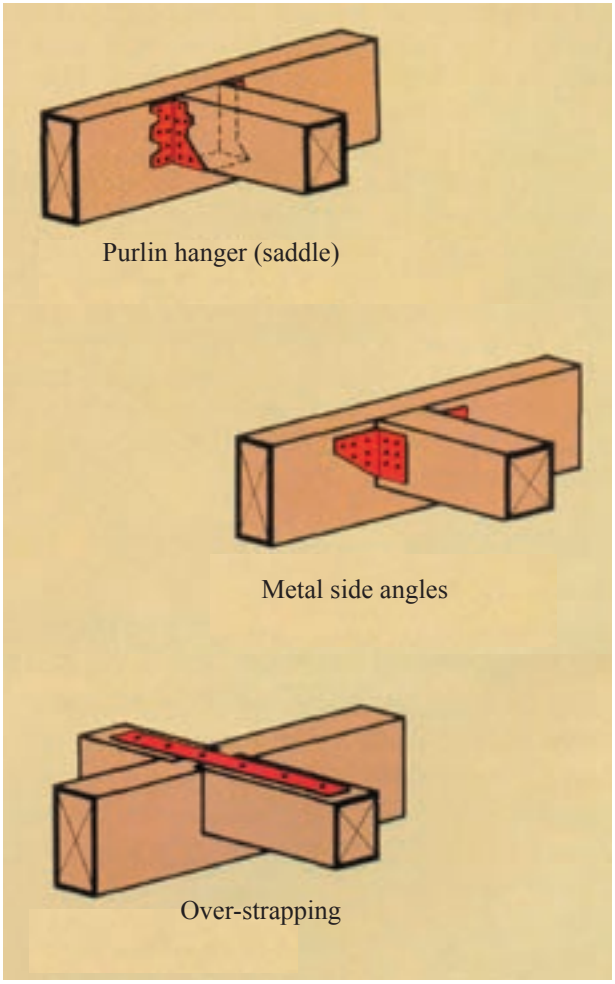


Figure 26 Purlin in-line with chord



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Exposed trusses reflect an extension of the main building roof shapes and create a sculptured facade

Double parrallel chord truss supports clearstrorey roof structure. Note vertical webs under point loads from clearstorey

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